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AIRCREW PERFORMANCE IN ARMY AVIATION.

Proceedings of a conference that convened November 27 - 29, 1973 at the U.S. ARMY AVIATION CENTER, FORT RUCKER, ALABAMA

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PREFACE

The Conference described in these Proceedings had two main purposes: to describe ongoing work in Army aircrew performance, and to identify the Army's requirements for behavioral research to enhance its aviation operations. One hundred and forty conferees (operational pilots, research scientists, and military planners) from the United States military and naval services, government and industry, together with representatives of three foreign countries, listened to a great variety of papers and participated in discussion groups addressing important aircrew questions.

This volume is a record of what they heard and what they discussed. Out of their discussions and the work of the committee responsible for developing the conference, a program of research to support the changing and increasing demands of Army aviation has been developed. It is to be hoped that those who read these Proceedings will carry on the effort initiated by the conference, an effort which should ultimately lead to significant improvements in Army aviation effectiveness.

CHARLES D. DANIEL, JR.
Major General, GS
Director of Combat Support Systems
Office of the Chief of Research,
Development and Acquisition

ACKNOWLEDGMENTS

The conference was planned and implemented over many months by the following, who formed the Executive Committee:

DR. JOSEPH ZEIDNER, Chairman, U.S. Army Research Institute for the Behavioral and Social Sciences

MR. ADRIAN DUBUISSON, Operational and Test Evaluation Agency

MR. CLARENCE FRY, Human Engineering Laboratory

DR. MARK HOFMANN, U.S. Army Aviation Center Team

MAJ MATTHEW R. KAMBROD, Deputy Chief of Staff, Operations

DR. DAVID MEISTER, U.S. Army Research Institute for the Behavioral and Social Sciences

DR. WALLACE PROPHET, Human Resources Research Organization

MR. EMIL SPEZIA, U.S. Army Agency for Aviation Safety

DR. JAMES J. McGRATH of Anacapa Sciences, Inc., was extremely helpful in assisting the Committee and in editing these Proceedings.

Special thanks are due to MG WILLIAM MADDOX, JR., Commander, U.S. Army Aviation Center, Fort Rucker, Alabama, who hosted the conference.

The logistical amenities which contributed so much to the success of the conference were coordinated with untiring effort by MAJ CHARLES JAMES of the Army Aviation Center.

Recognition must also be given to participants, foreign visitors, session chairmen, discussion leaders, and particularly to authors, all of whom contributed to the stimulating atmosphere of the conference.

These Proceedings were compiled, edited, and published by the staff of the U.S. Army Research Institute for the Behavioral and Social Sciences.

DR. J. E. UHLANER
General Chairman,
OCRDA Conference on Aircrew
Performance in Army Aviation

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TECHNICAL PAPERS (CONT.)

VISUAL ACTIVITIES OF THE HELICOPTER PILOT DURING LOW-ALTITUDE, VFR FLIGHT

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BELL HELICOPTER COMPANY

STATEMENT OF THE PROBLEM

This paper addresses a vital problem which dictates the success or failure of very low altitude flight missions. The problem involves the visual capabilities of the helicopter pilot during low altitude, VFR flight. It may be defined as establishment of the pilot's visual workload. To study this involves defining the visual work activity framework within which to measure visual workload.

The urgency of this problem stems from the trend to add to the pilot's existing tasks. He is now asked, in fighter and scout helicopters, to perform two new tasks: (1) to increase his surveillance activities in the target area since the gunner is becoming a head-down crew member during attack and search mission phases, and (2) to act as a substitute gunner by using a helmet mounted sight and a headtracker to direct turret mounted weapons or armament. These tasks must be performed in addition to the extremely demanding task of nap-of-the-earth flight. We are examining the problem of how much visual time the pilot has to perform these tasks. Continuing studies must define the time required of these additional tasks so that the time required can be matched with the time available. Any overburdening of the pilot must be addressed by tactical and operational planners.

DEFINING VISUAL WORKLOAD

We shall refer to visual workload as those visual activities which are necessary for the accomplishment of the mission. This by no means separates it from the other types of workload required of the operator, such as the manual workload, the auditory workload, and the cognitive workload. Certainly these all combine to result in the total workload. In attempting to define the visual task, many studies have used the technique of photographing the eyes. The results of these studies provide data on eye fixations of foveal vision and have application to IFR conditions, but because they cannot identify activity in the periphery, their application to VFR flight seems limited.

It is our thesis that the experienced helicopter pilot, flying VFR, has developed an extremely sophisticated visual scan procedure, that he relies heavily on peripheral viewing techniques, and that his scan pattern priorities change dramatically as a function of altitude and maneuver, particularly during nap-of-the-earth flight in helicopters.

A series of short flight studies has convinced us that there may be a means of identifying the pilot's visual activity during VFR flight which then permits defining the VFR visual workload. This combines subjective reports from the pilot himself and the construction of an ancillary visual task, completely irrelevant to the flight task. The performance on this additional task can be quantified in terms of duration and frequency and will give an estimate of foveal visual or fixation activity without interferring with the normal visual field of the pilot. Performance on this additional task we have called visual free time (VFT), and it may be used to estimate time available for any added visual tasks the pilot could be asked to perform.

THREE STUDIES

HELMET-SIGHT STUDY

One study, performed with the U.S. Army Night Vision Labs (Bell Helicopter Company, 1973) was designed to examine total pilot performance during low-level flight using a helmet-mounted CRT with a daylight TV image. The TV camera, mounted in a turret on the front of a HU-1

helicopter was directed by the pilot's head through a mechanical headtracker.

Video tape, taken to provide proof of the success of the flight, was examined later to assist in defining visual activities. This was achieved by measuring the direction of turret position and thus the area of general visual scan the pilot desired.

The pilot successfully and without assistance performed the following maneuvers:

- takeoff and climb
- cruise
- search for navigation fix and letdown
- low altitude, terrain following flight
- approach and land

For scoring purposes, three pitch positions and two azimuth positions were identified. Pitch scores compared TV position with the horizon line, 0° to 5° down, 5° to 10° down and over 10° down. Total field of view in pitch was ± 10°, thus in the third position the pilot was unable to see the horizon. Azimuth scoring employed only the dichotomous score relating to a longitudinal or pilot centerline index. Scores indicated if the picture was in or outside of the picture. The field of view in azimuth was ± 15°. Figure 1 shows these positions. Use of these positions varied with the maneuver. During take-off and cruise maneuvers, approximately half of the time the turret position was at zero, during landing approach, 83 percent of the turret time was at this position. As the aircraft approached NOE flight, larger and larger percentages of time were spent looking down. Figure 2 shows the relationship of percent of total time spent for each maneuver with the turret in one of the three pitch positions.

Of equal interest are the times spent in each position. These turret position times, representing visual scan time, decrease in duration as altitude decreases. As may be seen in Figure 3, the change is from approximately six seconds per scan to one second per scan. The turret position used the greatest percentage of the total time and has been labeled "normal" and scan excursions from that position were measured.

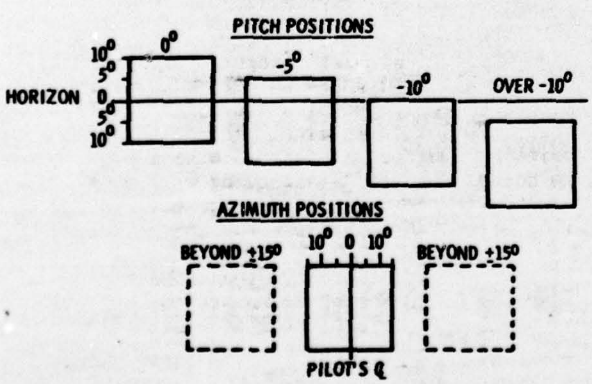

Figure 1. TV/turret positions for scoring.

Scan excursions in azimuth are presented in Figure 4. Here again the total percent of time spent in any one turret position changes from maneuver to maneuver. For NOE flight the pilot is using his azimuth movement capability for much larger percentages of the total time than during other maneuvers. The latency scores for these data are presented in Figure 5 where all excursions in azimuth are indicated as utilizing one to three seconds.

This study pointed up the changing pattern and time segments in visual scan techniques during VFR flight at low altitudes.

SUBJECTIVE REPORT STUDY

A different study attempted to determine visual scan patterns during VFR flight by utilizing the straightforward technique of asking the pilot where he was looking (Bell Helicopter Company, 1972). Data were recorded on a tape recorder through an open mike. The pilot was to

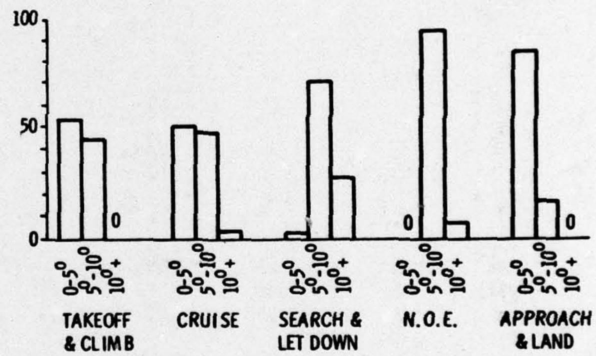

Figure 2. Percent total time of pitch positions.

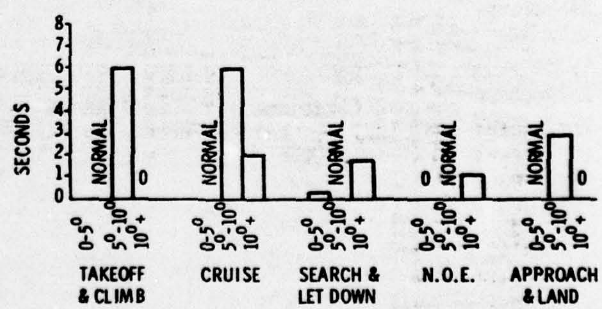

Figure 3. Viewing time for pitch positions.

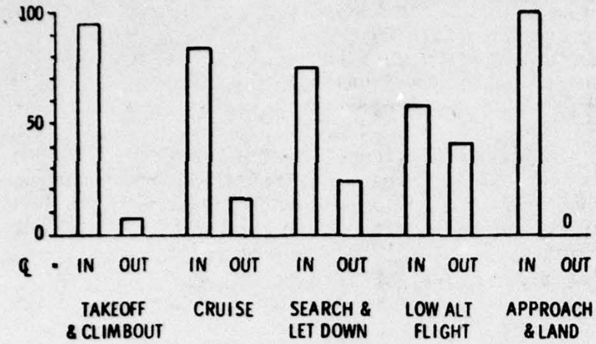

Figure 4. Percent total time of azimuth positions.

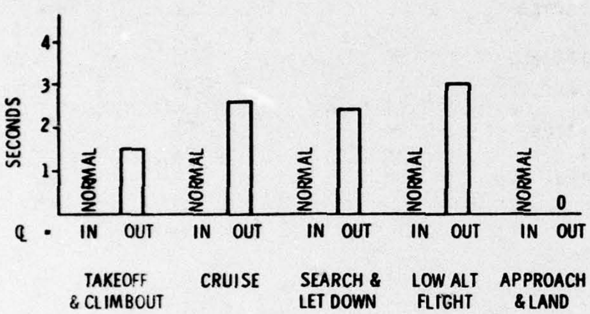

Figure 5. Viewing time for azimuth positions.

talk into the mike almost continuously, reporting where he was looking. Samples of recorded scan segments included: outside, altimeter, airspeed, caution panel, and engine cluster. Data were collected on four different maneuvers. The first three were straight-and-level or level-with-terms. The fourth was a landing approach.

The interesting point for this discussion was that under normal conditions, the pilot spends as much as approximately 80 percent of his time looking outside of his aircraft. Figure 6 presents the total percentage of time spent looking both inside and outside on the four maneuvers.

VISUAL FREE TIME STUDY

With the modification to the Bell AH-1G to accept the TOW missile, the requirement to study the visual workload of the pilot became increasingly important. To study this we drew on previous experience with a secondary visual task, to load and overload a pilot, developed for a simulator evaluation study (Bell Helicopter Company, 1973). For the current project, the pilot was asked to attend to the task when he was not performing any other visual task, either inside or outside the helicopter. Safety of

MANEUVER	TOTAL TIME	LOOK OUTSIDE HELICOPTER	LOOK INSIDE HELICOPTER
CRUISE	8 MIN	74.5%	25.5%
CRUISE WITH TURNS	6 MIN 10 SEC	67.3%	32.7%
CRUISE WITH TURNS	7 MIN	81.4%	18.6%
APPROACH TO LAND	2 MIN	81.4%	18.6%

Figure 6. Percent total time of pilot visual activity.

flight was to be considered of prime importance.

The task was a reading task of random words. Data were recorded through an open mike on tape. The visual stimulus was placed in a position close to the pilot centerline on the panel.

Three pilots performed the task of flying straight and level over known terrain in perfect VFR conditions at each of three absolute altitudes: 300 feet, 100 feet, and NOE, or as low as they felt safe. NOE resulted in an altitude judged by observers and copilots to be approximately 25 to 75 feet over terrain or treetops and has been labeled at 50 feet in the figures. Each run was approximately two minutes long and was flown at 80 knots. The terrain included river bottom land, open fields, heavy tree growth, and combined open fields with intermittant trees.

The results, as indicated in Figure 7, show visual activity in terms of visual free time or the time the pilot spent performing the added visual task. Data points are plotted for each pilot and represent a mean of his runs at the indicated altitude. The solid line represents the mean of all data points. Large individual differences are indicated at 300 feet where the spread is from 17 percent VFT to 77 percent VFT. This reduces at NOE to a much smaller, and probably insignificant, spread.

One run was made with each pilot at the 300 foot altitude where the stimulus material was presented to the pilot 90° off axis from the aircraft/pilot centerline. The dashed line begins at 300 feet at this point and parallels the solid line, thus indicating what might be expected in terms of visual free time if the pilot were scanning ± 90° from centerline.

The figure indicates that when flying NOE under the optimal conditions stated, the pilot has no more than 15 percent of his total time that he could attend to any added visual task.

The next piece of information needed in order to apply these kinds of data to a workload

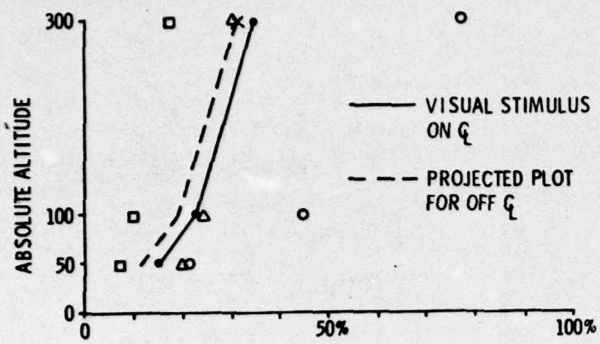

Figure 7. Percent visual free time.

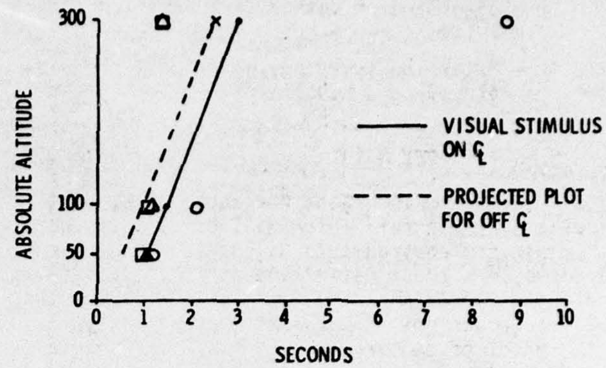

Figure 8. Time per scan interval.

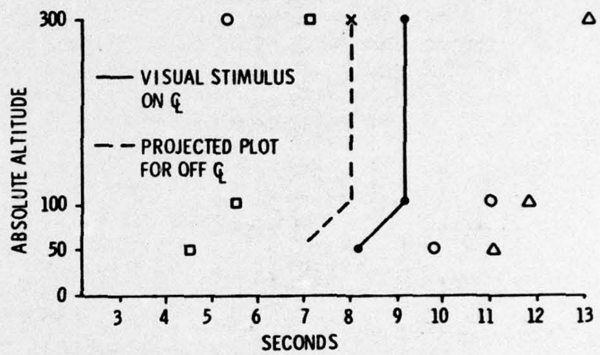

Figure 9. Scan intervals per minute.

format is the useful visual scan interval of which the 15 percent VFT is composed. Figure 8 shows the length of the scan interval as a function of altitude. Again there are wide differences at 300 feet but at 100 feet and 50 feet these reduce to probable insignificance. Thus, NOE flight permits the pilot no more than one second duration scan intervals. This corresponds with the data from the TV study. The single data point at 300 feet of the off-axis data, when projected parallel to the on-axis data, indicates that for a one second scan interval, the pilot must be at 100 feet. NOE he will have only a fraction of a second.

The manner in which the pilots chose to distribute these short scan intervals may be seen in Figure 9. These data are not as homogeneous as those of the previous figures. Wide individual differences may be seen from the individual plots of the data points. Means indicate, however, that there are approximately nine scan segments per minute and if these averages are representative, this behavior does not change drastically as a function of altitude.

The following general applications may be drawn from these small studies and sparse data:

- The pilot changes priorities of visual scan sequences with VFR maneuvers and with altitude
- the duration and frequency of visual scan intervals change between NOE and 300 feet of altitude
- below 100 feet, any demands on the pilot's time can only be of the simplest type unless he is unburdened from his visual tasks.

If changes in pilot visual performance are to be achieved, there are two avenues which the aircraft system planners and designers should investigate. The first may be to provide automatic sensing devices to supplement some of the visual tasks the pilot must perform. The second may be to divide responsibilities between crew members.

A more definitive and applied look at visual behavior in the flight environment is in order. These few flight studies, however, suggest a quick means of gathering the data needed now without altering the visual environment. These data are required for HFE and behavioral scientists for both analyses of the human in the system and for definitions of pilot workload.

We would suggest the following areas of study be seriously investigated.

(1) Visual workload criteria should be gathered at night, during hover, and on a large population of operational pilots to:

- determine total duration for safe flight at NOE
- define total visual areas pilots can scan at various altitudes
- study effect of speed.

These tests should be conducted when the pilot is over unfamiliar terrain and when the pilot is required to navigate.

(2) Unburdening the pilot's visual channel should be studied to:

- determine effect of task distribution between crew members
- determine symbology which could be displayed on a HUD
- examine techniques of utilizing auditory advisory data.

The need is urgent for these data. Detail designs of aircraft which will be asked to perform in the environments discussed are now in process. Without definitive data, only estimates of pilot performance at low altitude can be made for such designs. We risk the possibility that the pilot of tomorrow may be the limiting element in total system performance.

REFERENCES

Bell Helicopter Company. *UTTAS human factors engineering, design approach substantiation.* Technical Report 299-929-005, March 1972, pp 6-27 to 6-32.

Bell Helicopter Company. *TV eyeglass display/headtracker tests for Night Vision Laboratory, Fort Belvoir, Virginia, Task I.* Technical Report 299-099-664, August 1973.(a)

Bell Helicopter Company. Visual free time study. In *Human factors engineering final report on the improved Cobra armament program.* Technical Report 209-099-381, August 1973. (b)

Dougherty, D. J., Emery, J. H., & Curtin, J. G. *Comparison of perceptual workload in flying standard instrumentation and the Contact Analog Vertical Display.* Bell Helicopter Company, Technical Report D228-421-019, December 1964.